DOI: https://doi.org/10.52756/ijerr.2026.v50.013 *Int. J. Exp. Res. Rev.*, Vol. 50: 165-172 (2026)

Review Article | *Peer Reviewed* | *Open Access*

International Journal of Experimental Research and Review (IJERR)
© Copyright by International Academic Publishing House (IAPH)
ISSN: 2455-4855 (Online)
www.iaph.in
ISSN 2455-4855

Optimization of Solar Drying Parameters for Nutrient Retention in Carica papaya Leaves: A Comprehensive Review

Prashant Pandit and Nilesh Diwakar*

Sarvepalli Radhakrishnan University (SRKU), Bhopal, Madhya Pradesh- 462026, India

E-mail/Orcid Id:

PP, plpandit@gmail.com, https://orcid.org/0009-0000-7830-4563;
ND, nileshdiwakar@yahoo.com, https://orcid.org/0000-0003-4055-6145

Article History:

Received: 06th Jan., 2026
Accepted: 11th Apr., 2026
Published: 30th Apr., 2026

Keywords:
Papaya leaves, Solar drying, Response Surface Methodology, RSM, nutrient retention, Vitamin C, flavonoids, Antioxidants, Box-Behnken design, Optimization

How to cite this Article:
Prashant Pandit and Nilesh Diwakar (2026). Optimization of Solar Drying Parameters for Nutrient Retention in *Carica papaya* Leaves: A Comprehensive Review. *International Journal of Experimental Research and Review, 50*, 165-172.
DOI:

Abstract: Papaya leaves (*Carica papaya*) contain high protein (25.75%), carbohydrates (41.49%), flavonoids (21.00mg QE/g), phenolics, antioxidants, vitamins, and bioactive compounds with proven medicinal properties against dengue, diabetes, malaria, and inflammation. Their perishability, however, makes them require effective drying to preserve them. Solar drying is a sustainable, low-energy technology, but the majority of systems do not provide control over temperature, humidity and airflow levels, leading to uneven drying and severe loss of heat-sensitive nutrients. The current methods are based on experimentation, concentrate more on moisture elimination, and seldom use Response Surface Methodology (RSM) or regression analysis to retain nutrients. The review presents these research gaps as critical and suggests the Box-Behnken Design-based RSM to maximize the retention of Vitamin C, flavonoids and antioxidants by optimizing the key parameters temperature, airflow velocity and drying time. The optimized solar drying system should provide a consistent quality, better nutrient conservation, energy saving and a predictive model to be used in industries.

Introduction

One of the most commonly used post-harvest preservation processes in food and medicinal plants processing is drying with the aim of minimizing moisture content to hinder microbial growth and increase shelf life. Although effective, drying is an energy-consuming process that can have a considerable impact on the quality of the product, especially by degrading heat-sensitive nutrients and bioactive compounds (Belwal et al., 2024; Mujumdar, 2025).

Carica papaya leaves have attracted considerable interest owing to their nutritional and therapeutic value. They are rich in crude protein (25.75%), carbohydrates (41.49%) and the presence of essential minerals like potassium (4071 mg/kg), calcium (1079 mg/kg), magnesium (789.2 mg/kg) and iron (228.2 mg/kg) (Choudhary et al., 202 Moreover, papaya leaves are rich in bioactive compounds such as flavonoids, phenolics, tannins, and alkaloids that have a high antioxidant potential based on DPPH and FRAP tests (Yap et al., 2020; Yap et al., 2022; Choudhary et al., 2025). Papaya leaves are linked to many pharmacological effects, including antimicrobial, anti-inflammatory, antidiabetic, and anticancer effects, and thus papaya leaves are very useful in the functional food and nutraceutical industry (Belwal et al., 2024; Choudhary et al., 2025).

Nevertheless, fresh papaya leaves are extremely perishable due to their high moisture content, leading to rapid microbial spoilage and degradation of bioactivity (Kumar, 2016; Olatunya, 2023). Thus, effective drying methods are necessary to increase shelf life and microbial safety, and to enable their use in the food and

*Corresponding Author: nileshdiwakar@yahoo.com

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

pharmaceutical sectors (Belwal et al., 2024; Mujumdar, 2025).

The drying method is a very critical factor in the overall quality of the end product. The most common traditional approaches include open-sun drying and hot-air drying because of their simplicity and low cost; nevertheless, they often result in uneven drying, contamination, and high degradation of bioactive compounds (Văn Lực & Văn Hiếu, 2024; Gutiérrez et al., 2023). Drying methods such as freeze drying, microwave drying, and vacuum drying have shown better nutrient preservation but are associated with high operating costs and limited scalability (Belwal et al., 2024; Belonio et al., 2025).

Another alternative that has been introduced as sustainable and energy-saving is solar drying, especially in tropical areas like India. It offers benefits such as lower energy use, a smaller environmental footprint, and higher product quality than traditional open-sun drying (Gaur, 2021; Nwakuba, 2019). Nevertheless, the majority of solar drying systems are characterized by shortcomings, including the inability to control temperature, humidity, and airflow, which result in uneven drying, weather-dependency, and the loss of heat-sensitive nutrients, including vitamin C, flavonoids and antioxidants (Parhizi et al., 2022; Belwal et al., 2024).

In order to overcome these restrictions, drying parameters, including temperature, airflow velocity and drying time, need to be optimized in order to improve drying efficiency without losing nutrients. Traditional statistical and numerical methods like Response Surface Methodology (RSM) and Artificial Neural Networks (ANN) have been extensively used to simulate and optimize the drying processes and allow establishing predictive correlations between the process variables and the quality characteristics (Demir et al., 2023; Golpour et al., 2020; Parhizi et al., 2022). Nevertheless, the current literature is based on trial-and-error methods and is mainly oriented toward moisture elimination and little attention to nutrient conservation and predictive optimization.

Thus, this review will critically examine the drying properties of Carica papaya leaves by evaluating alternative drying methods, especially solar drying systems and optimization measures. The paper also determines the research gaps that exist and suggests the use of Box-Behnken design under RSM in order to maximize the important drying parameters- temperature, airflow velocity and drying time- that would increase nutrient retention and enhance drying efficiency.

Nutritional, Phytochemical & Medicinal Characteristics of the Carica papaya Leaves

Carica papaya leaves are known to be an excellent source of nutrients and bioactive compounds, thus making them very useful in functional foods, nutraceuticals, and pharmaceuticals. They contain the necessary macronutrients, minerals, and various phytochemicals, making them biologically and therapeutically active.

Table 1. Nutritional Composition of *Carica papaya* Leaves.

Component	Concentration	Functional Significance
Protein	25.75%	Growth, tissue repair
Carbohydrates	41.49%	Energy source
Potassium (K)	4071 mg/kg	Electrolyte balance, heart function
Calcium (Ca)	1079 mg/kg	Bone health
Magnesium (Mg)	789.2 mg/kg	Enzyme activation
Sodium (Na)	361.2 mg/kg	Fluid balance
Iron (Fe)	228.2 mg/kg	Hemoglobin formation
		Source: Choudhary et al., 2025

Nutritional Composition

The leaves of papaya have a considerable nutritional content, especially because they contain high amounts of protein and carbohydrates. They have around 25.75% crude protein and 41.49% carbohydrates and this means that they can serve as a supplementary diet (Choudhary et al., 2025). Besides macronutrients, papaya leaves contain vital minerals like potassium (4071 mg/kg), calcium (1079 mg/kg), magnesium (789.2 mg/kg), sodium (361.2 mg/kg), and iron (228.2 mg/kg) that help in metabolism processes, enzyme activities, and physiological functions.

Nevertheless, processing methods, especially drying, have a very strong influence on the preservation of these nutrients, and when inappropriate conditions are used, they can be destroyed and deprived of their nutritional value.

Phytochemical Composition

Papaya leaves are rich in phytochemicals such as flavonoids, phenolic compounds, tannins, alkaloids, and

DOI: https://doi.org/10.52756/ijerr.2026.v50.013

saponins, which contribute to their strong antioxidant and therapeutic properties. Quantitative studies report flavonoid content of approximately 21.00 mg QE/g and phenolic content of 8.85 mg GAE/g (Choudhary et al., 2025). These compounds exhibit high antioxidant activity as confirmed by DPPH and FRAP assays (Yap et al., 2020).

Table 2. Major Phytochemicals and Their Biological Functions.

Phytochemical	Approx. Content	Biological Function
Flavonoids	21.00 mg QE/g	Antioxidant, anti-inflammatory
Phenolics	8.85 mg GAE/g	Free radical scavenging
Tannins	430 mg TAE/g	Antimicrobial, astringent
Alkaloids	-	Antimalarial, therapeutic
Saponins	-	Immune modulation
Carpaine	-	Cardioprotective, antimicrobial
Yap et al., 2020; Yap et al., 2022; Choudhary et al., 2025		

Advanced analytical techniques such as FTIR, XRD and DSC confirm the presence of bioactive functional groups and indicate moderate thermal stability, although these compounds remain sensitive to drying conditions (Choudhary et al., 2025). Improper drying can degrade key compounds, such as polyphenols and carpaine, thereby reducing antioxidant capacity (Yap et al., 2022).

Medicinal and Therapeutic Properties

The presence of diverse phytochemicals imparts a wide range of medicinal properties to papaya leaves. These include antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and anticancer activities. Papaya leaf extracts have been traditionally used to treat dengue, malaria, diabetes, and digestive disorders (Choudhary et al., 2025).

Studies have reported strong antimicrobial activity against pathogens such as Escherichia coli, Staphylococcus aureus, Bacillus subtilis, and Klebsiella pneumoniae, with inhibition zones ranging from 22.05 to 25.15 mm (Choudhary et al., 2025; Belwal et al., 2024). Additionally, papaya leaves exhibit immunomodulatory effects, particularly by enhancing platelet counts in dengue patients, as well as antiviral and wound-healing properties (Belwal et al., 2024).

Effect of Drying on Nutritional and Phytochemical Properties

Although drying is essential for preservation, it significantly affects the retention of nutrients and bioactive compounds. Papaya leaves are highly sensitive to drying conditions because they contain heat-sensitive components such as vitamin C, flavonoids, and polyphenols.

Studies indicate that:

1. High drying temperatures accelerate the degradation of antioxidants and vitamins
2. Extended drying time reduces phenolic and flavonoid content
3. Non-uniform airflow leads to uneven drying and quality deterioration (Yap et al., 2020; Prajapati et al., 2022; Tallei et al., 2024)

Advanced drying techniques such as freeze drying and microwave-vacuum drying provide better retention of bioactive compounds but are costly and less feasible for large-scale applications (Belwal et al., 2024; Belonio et al., 2025). Therefore, optimizing drying parameters is essential to balance efficiency and quality.

Critical Insight and Research Need

Despite extensive research on the nutritional and medicinal properties of papaya leaves, there is limited understanding of the quantitative relationship between drying parameters and nutrient retention. Most studies focus on qualitative analysis or individual drying techniques, with minimal emphasis on predictive modeling and optimization.

Furthermore, the integration of advanced tools such as Response Surface Methodology (RSM) and Artificial Intelligence (AI) for optimizing drying conditions remains underexplored. This highlights the need for systematic and data-driven approaches to develop efficient drying systems that maximize nutrient preservation while ensuring energy efficiency and scalability.

Drying Mechanisms and Principles

Drying removes moisture from solids via simultaneous heat and mass transfer, converting liquid water to vapor (requiring ~2258 kJ/kg at 101.3 kPa). Heat is delivered to the surface and penetrates inward, while moisture migrates by diffusion (homogeneous solids), capillary flow (porous materials), shrinkage/pressure differences, gravity, or vaporization-condensation cycles (Belwal et al., 2024; Mujumdar, 2025).

Moisture content is expressed on wet basis Xw =

DOI: https://doi.org/10.52756/ijerr.2026.v50.013

mw/(mw + md) or dry basis Xd = mw/md. In solar and convective drying, external convection governs surface evaporation, while internal mechanisms control the falling-rate period. These principles determine drying rate, energy efficiency, and retention of heat-sensitive nutrients in papaya leaves (Gaur, 2021; Parhizi et al., 2022).

Drying starts with the introduction of external energy in the form of hot air or solar radiation, which is transferred to the leaf surface by convective and radiative heat transfer. The higher the surface temperature, the higher the free moisture on the leaf surface evaporates, as shown by the area of moisture evaporation in the diagram. This phase corresponds to the constant-rate drying phase, where the moisture content rate is elevated and is mainly influenced by external factors, including temperature, airflow and humidity (Mujumdar, 2025; Belwal et al., 2024). After surface moisture evaporates, internal moisture moves down the leaf's internal structure to the surface due to moisture concentration gradients and vapor pressure differences. The arrows shown in this figure depict moisture migration. In the leaf matrix, the transport of moisture takes place primarily in the form of diffusion and capillary flow. Diffusion is the process of transfer of moisture to areas of increased concentration from areas of reduced concentration, and the flow of liquid is the process of transporting liquid by the porous, cellular structure of the leaf (Teng & Lee, 2015; Mujumdar, 2025). These processes prevail during the falling-rate period, where the drying rate tends to slow and is dependent on internal mass-transfer resistance (Zambra et al., 2021). The drying process is a cyclic process involving input of heat, surface evaporation and internal movement of moisture till an equilibrium moisture content is achieved. Altogether, the figure illustrates that drying is a combination of heat and mass transfer, where heat transfer provides the required energy for evaporation, whereas mass transfer governs the movement of moisture within the material. This mechanism is important to optimize the drying parameters, including temperature, airflow velocity, and drying time, because when it is not properly controlled, non-uniform drying of papaya leaves and degradation of heat-sensitive nutrients, including flavonoids and antioxidants, can occur (Golpour et al., 2020; Parhizi et al., 2022; Demir et al., 2023).

Optimization Techniques in Drying

The limitations of trial-and-error in optimization are addressed by mathematical modeling of the interactions among drying inputs (temperature, airflow velocity, drying time) and the primary responses (nutrient retention, drying rate, energy efficiency).

- Response Surface Methodology (RSM) is the most commonly used tool. It is based on Box-Behnken Design (BBD) or Central Composite Design in order to generate a structured set of experiments at three coded levels (−1, 0, +1). A second-order polynomial model is fitted: Response = $\beta_0 + \Sigma\beta_i X_i + \Sigma\beta_{ii} X_i^2 + \Sigma\beta_{ij} X_i X_j + \varepsilon$
- ANOVA establishes the significance of models, linear/quadratic effects, and interactions. The optimum region is determined by 3D surface and contour plots. The basil leaf hybrid-solar drying and Houttuynia cordata solar drying have been successfully carried out using RSM to maximize bioactive retention (Teng and Lee, 2015; Golpour et al., 2020; Parhizi et al., 2022; Kreetachat et al., 2023; Demir et al., 2023).
- Artificial Neural Networks (ANNs) are good predictors of non-linear drying kinetics and quality parameters and may be combined with RSM or genetic algorithms to optimize multiple objectives (Demir et al., 2023; Sadadou et al., 2021; Yudhistira et al., 2024).
- Other methods include multiple regression as a predictive model, energy/exergy analysis, and parametric-based algorithms, such as the Firefly algorithm, for drying papaya using osmosis (Yeomans and Imanirad, 2014; Nwakuba, 2019; Mujumdar, 2025).
- These techniques enable accurate predictive control and optimal preservation of Vitamin C, flavonoids and antioxidants in papaya leaves during solar drying.

Current Challenges in Solar Drying of Medicinal Leaves

The use of solar drying in processing medicinal leaves such as Carica papaya faces several severe constraints that undermine product quality and efficiency.

- Sensitivity to climatic conditions: The system's performance is highly sensitive to weather conditions; rainy, cloudy, or unstable sunlight conditions reduce drying efficiency and increase the risk of spoilage (Gaur, 2021; Mujumdar, 2025).
- The inability to control temperature, humidity, and airflow: The majority of low-cost solar dryers cannot control the specified parameters, which leads to uneven drying and faster degradation of heat-sensitive nutrients (Vitamin C, flavonoids, antioxidants) (Parhizi et al., 2022; Kreetachat et al., 2023; Belwal et al., 2024).
- Poor airflow distribution: The improper design leads to uneven tray drying, with some areas remaining wet and others over-dried, which affects product uniformity (Nwakuba, 2019).

DOI: https://doi.org/10.52756/ijerr.2026.v50.013

- Loss of nutrients and deterioration of quality: Long-term high-temperature conditions and prolonged drying periods degrade bioactive compounds, reducing their nutritional and medicinal value to a minimum (Yap et al., 2020; Yap et al., 2022; Olatunya, 2023).
- Design and standardization concerns: The lack of standardized solar dryer designs across crops leads to inconsistencies and challenges in replicating results (Demir et al., 2023).
- Limitations of monitoring and automation: Hand operation and the absence of real-time monitoring increase labor costs, reduce repeatability, and decrease efficiency (Gaur, 2021).
- High start-up and economic barriers: Sophisticated systems with adequate controls are costly and small-scale farmers and the rural population can not afford them (Nwakuba, 2019).
- The issues of material handling and post-drying storage: Inappropriate handling reintroduces moisture and contaminants, reducing the shelf life (Mujumdar, 2025).
- Ignorance and technical illiteracy: Due to limited awareness, most users do not use it optimally, leading to ineffective use and poor practices (Gaur, 2021).
- Dependency on trial-and-error optimization: The drying parameters are not scientifically optimized in most studies; most studies do not use RSM or regression analysis to model nutrient retention (Golpour et al., 2020; Demir et al., 2023).
- These difficulties underscore the pressing need to enable controlled, optimized solar-drying systems for papaya leaves.

Research Gap and Problem Statement

Drying conditions (temperature, airflow velocity, time) are not always chosen scientifically but are usually determined using trial and error (Demir et al., 2023; Golpour et al., 2020). Advanced methods such as Response Surface Methodology (RSM) and regression analysis are not fully utilized and there are no predictive models to correlate input variables with nutrient retention (Parhizi et al., 2022; Kreetachat et al., 2023; Nwakuba, 2019). The literature already shows substantial moisture removal and a relative lack of nutrient retention as response variables (Nwakuba, 2019; Belwal et al., 2024).

Problem Statement: Papaya leaves contain abundant bioactive compounds, yet they are very perishable. The existing solar drying technologies lead to uncontrolled, weather-dependent drying, which kills heat-sensitive nutrients and produces variable quality. In the absence of RSM-based optimization, no predictive relationship with confidence is established linking the drying parameters to the maximum nutrient retention. There is an urgent requirement for a controlled, RSM-optimized solar drying system to achieve uniform drying, preserve Vitamin C, flavonoids and antioxidants and enhance energy efficiency for industrial applications.

Expected Outcomes and Future Directions

Projected Outcomes: It is believed that optimizing the solar drying of Carica papaya leaves using the most advanced statistical and computational methods will bring significant improvements to product quality and process efficiency. Through the combination of Response Surface Methodology (RSM) with controlled drying systems, uniform drying conditions, increased nutrient retention, and less energy usage can be attained. It is expected that optimized drying conditions, like temperature, airflow velocity, and drying time, will reduce the deterioration of heat-sensitive bioactive compounds, such as vitamin C, flavonoids, and phenolics, to preserve the medicinal and nutritional value of papaya leaves (Yap et al., 2020; Belwal et al., 2024).

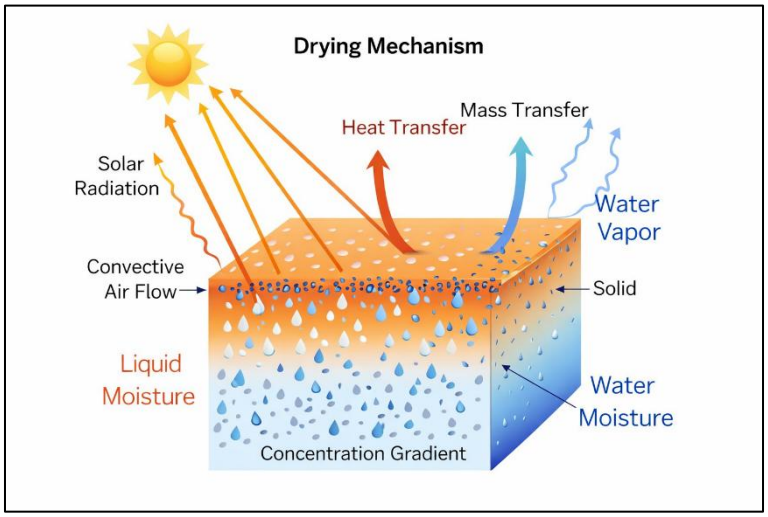

Figure 1. Schematic Representation of Drying Mechanism.

DOI: https://doi.org/10.52756/ijerr.2026.v50.013

One of the key anticipated results of this strategy is the creation of a predictive mathematical model that can be used to determine associations between input parameters and output responses, such as nutrient retention, moisture content and moisture drying efficiency. These models can substantially reduce reliance on empirical trial-and-error approaches and enable accurate prediction of desirable drying conditions (Parhizi et al., 2022; Demir et al., 2023). Also, Box-Behnken Design in RSM is likely to yield a high-accuracy experimental design with a reduced number of runs. In engineering, the use of optimized solar drying systems will enhance heat and mass transfer, reducing drying time and increasing product uniformity. Better airflow distribution mechanisms and thermal insulation can also improve system performance and energy consumption (Gaur, 2021; Mujumdar, 2025). These advancements will help to create cost-effective and sustainable drying technologies for rural and small-scale use. Moreover, improved drying methods will enhance the commercial viability of papaya leaf products by guaranteeing consistent quality and a long shelf life. This can facilitate their application in the pharmaceutical, nutraceutical and functional foods industries, thus enhancing the economic value of agricultural by-products and supporting agro-based industries. Further, the optimized system is to be scaled-up to an industrial application, hybrid solar-ANN models developed, real-time IoT monitored, applied to other medicinal leaves, the cost and sustainability of the life-cycle analyzed, and integrated with thermal storage to operate independently of weather conditions (Gaur, 2021; Yudhistira et al., 2024; Mujumdar, 2025).

Conclusion

The review has extensively explored the drying properties of Carica papaya leaves in relation to solar drying systems and nutrient restoration strategies. Papaya leaves contain many essential nutrients and bioactive compounds, including flavonoids, phenolics and antioxidants, which have high medicinal value. Nevertheless, they are very moist and heat-sensitive, requiring controlled drying methods to maintain their nutritional and therapeutic quality. Although common, conventional drying techniques are notorious for producing uneven drying and significant loss of heat-sensitive compounds because the process parameters cannot be controlled. An energy-efficient and sustainable option is solar drying, but current systems are constrained by weather dependence, an inability to control temperature, humidity, airflow and limited standardization and automation. These restrictions cause uneven drying, poor product quality and wasteful energy use. The review points out that optimization methods such as Response Surface Methodology (RSM) and Artificial Neural Networks (ANN) are fundamental to overcoming these obstacles. RSM, especially with BoxBehnken Design, provides the opportunity to conduct a systematic analysis of the relationships among the most important process variables, namely, temperature, airflow velocity and drying time and their impacts on nutrient retention and drying efficiency. The regression analysis and ANOVA-based validation results for developing predictive models provide a scientific basis for determining optimal drying conditions. Moreover, the incorporation of AI-based solutions will increase prediction accuracy and further enable control of the process. In spite of these developments, there is a major research gap regarding the use of optimization methods in the specific application of solar drying of medicinal leaves, with emphasis on nutrient preservation. The majority of available research focuses on moisture removal and drying kinetics, while bioactive compound retention and process optimization receive little attention. Thus, an optimized solar drying system built on RSM is a necessary measure to achieve homogeneous drying, maximize nutrient retention and improve energy efficiency. These systems have the potential to develop sustainable, cost-effective and scalable medicinal plant drying technologies. Future research directions include smart control systems, hybrid drying technologies, and data-driven optimization strategies to improve performance and make them more industrially applicable. To sum up, solar drying and advanced optimization methods offer a promising approach to preserving the nutritional and medicinal value of Carica papaya leaves and thereby enabling their effective use in food, pharmaceutical, and nutraceutical products.

Conflict of Interest

None

References

Belonio, L. S. H., Varith, J., Jaturonglumlert, S., Narkprasom, K., Narkprasom, N., Arkanit, K., & Sujinda, N. (2025). Performance of microwave-vacuum drying on flavonoids and saponins availability in *Carica papaya* leaves. *Results in Engineering*, *25*, 104909. https://doi.org/10.1016/j.rineng.2025.104909

Belwal, T., Cravotto, C., Prieto, M. A., Venskutonis, P. R., Daglia, M., Devkota, H. P., ... & Cravotto, G. (2024). Effects of different drying techniques on the quality and bioactive compounds of plant-

based products: A critical review on current trends. *Food Science & Nutrition*, *12*(4), 2112-2135. https://doi.org/10.60692/sxp8p-g2712

Choudhary, R., Kaushik, R., Akhtar, A., Manna, S., Sharma, J., & Bains, A. (2025). Nutritional, phytochemical, and antimicrobial properties of *Carica papaya* leaves: Implications for health benefits and food applications. *Foods*, *14*(2), 154. https://doi.org/10.3390/foods14020154

Demir, H., Demir, H., Lončar, B., Pezo, L., Brandić, I., Voća, N., & Yilmaz, F. (2023). Optimization of caper drying using response surface methodology and artificial neural networks for energy efficiency characteristics. *Energies*, *16*(4), 1687. https://doi.org/10.3390/en16041687

Gaur, A. (2021). Enhancement and optimization of solar dryer: A review. *Advanced Research in Mechanical Engineering*, *10*(1). https://doi.org/10.51983/arme-2021.10.1.2950

Golpour, I., Kaveh, M. H., Amiri Chayjan, R., & Guiné, R. (2020). Optimization of infrared-convective drying of white mulberry fruit using response surface methodology and development of a predictive model through artificial neural network. *International Journal of Fruit Science*, *20*(sup3), S1471-S1490. https://doi.org/10.1080/15538362.2020.1774474

Gutiérrez, K., Alonso, J., Gamero, R., & Picado, A. (2023). Convective drying of papaya (*Carica papaya* L. 'Red Maradol') and banana (*Musa acuminata* (AAA Group) 'Gros Michel'). *Nexo Revista Científica*, *36*(5), 17288. https://doi.org/10.5377/nexo.v36i05.17288

Kreetachat, T., Imman, S., Suwannahong, K., Wongcharee, S., & Suriyachai, N. (2023). Response surface optimization and social impact evaluation of *Houttuynia cordata* Thunb solar drying technology for community enterprise in Chiangrai, Thailand. *International Journal of Renewable Energy Development*, *12*(3), 543-552. https://doi.org/10.14710/ijred.2023.52402

Kumar, P. V. (2016). A comparative study of phytochemical content in air dried and lyophilized *Carica papaya* leaves. *International Journal of Green Pharmacy*, *10*(4), S759. https://doi.org/10.22377/IJGP.V10I04.759

Lima, T. L. B., Santos, N. C., Almeida, R. L. J., Monteiro, S. S., Figueira, J., do Bomfim, K. A., ... & Rocha, A. P. T. (2025). Sequential pre-treatment strategies to improve papaya drying: Impact on mass transfer, morphology, and rehydration rate. *Journal of Food Process Engineering*, *48,* e70039. https://doi.org/10.1111/jfpe.70039

Mujumdar, A. S. (2025). Toward sustainable post-harvest practices: A critical review of solar and wind-assisted drying of agricultural produce with integrated thermal storage systems. *Drying Technology*. https://doi.org/10.6084/m9.figshare.29852256

Nwakuba, N. R. (2019). Optimisation of energy consumption of a solar-electric dryer during hot air drying of tomato slices. *Journal of Agricultural Engineering*, *49*(4), 214-222. https://doi.org/10.4081/JAE.2018.876

Olatunya, A. (2023). Effects of drying techniques and different solvents on phytochemical composition and antioxidant activity of *Carica papaya* seed extracts: Implications for industrial use and medicinal benefits. *Asian Journal of Chemistry*, *35*(12), 28159. https://doi.org/10.14233/ajchem.2024.28159

Parhizi, Z., Karami, H., Golpour, I., Kaveh, M. E., Szymanek, M., Blanco-Marigorta, A. M., ... & Darvishi, Y. (2022). Modeling and optimization of energy and exergy parameters of a hybrid-solar dryer for basil leaf drying using RSM. *Sustainability*, *14*(14), 8839. https://doi.org/10.3390/su14148839

Prajapati, M., Akbari, S. H., Bhatt, H. G., & Damle, K. S. (2022). Effect of drying on biochemical properties of papaya leaves. *International Journal of Innovative Research in Science, Engineering and Technology*, *11*(8). https://doi.org/10.5281/zenodo.7017987

Sadadou, A., Hanini, S., Laidi, M., & Rezrazi, A. (2021). Novel approach for predicting direct and open solar drying using artificial neural network for medicinal plant. *Kemija u industriji*, *70*(7-8), 409-418. https://doi.org/10.15255/KUI.2020.049

Singh, B., & Hathan, B. S. (2017). Process optimization of spray drying of beetroot juice. *Journal of Food Science and Technology*, *54*(8), 2241-2250. https://doi.org/10.1007/S13197-017-2659-8

Siriamornpun, S., Ratseewo, J., Kaewseejan, N., & Meeso, N. (2015). Effect of osmotic treatments and drying methods on bioactive compounds in papaya and tomato. *RSC Advances*, *5*(41), 32247-32256. https://doi.org/10.1039/C4RA16927A

Tallei, T. E., Sailah, I., Safitri, L., Tamala, Y., & Halimatushadyah, E. (2024). Impact of various drying methods on bioactive compounds in bitter

leaf (*Vernonia amygdalina* Del.). *The Philippine Journal of Science*, *153*(6B). https://doi.org/10.56899/153.6b.19

Teng, H., & Lee, W. Y. (2015). Drying kinetics and optimization for thin-layer drying processes of raspberries (*Rubus coreanus* Miq.) using statistical models and response surface methodology. *Korean Journal of Food Preservation*, *22*(1), 1-10. https://doi.org/10.11002/KJFP.2015.22.1.1

Udomkun, P., Nagle, M., Mahayothee, B., Nohr, D., Koza, A., & Müller, J. (2015). Influence of air drying properties on non-enzymatic browning, major bio-active compounds and antioxidant capacity of osmotically pretreated papaya. *LWT - Food Science and Technology*, *60*(2), 914-922. https://doi.org/10.1016/J.LWT.2014.10.036

Uribe, E., Vega-Gálvez, A., Pastén, A., Cantuarias, C., Stucken, K., García, J., ... & Delporte, C. (2022). Effect of high- and low-temperature drying methods on fatty acid profile and antimicrobial and anti-inflammatory traits of papaya (*Vasconcellea pubescens*). *ACS Food Science & Technology*, *2*(3), 481-490. https://doi.org/10.1021/acsfoodscitech.2c00288

Văn Lực, N., & Văn Hiếu, T. (2024). Comparison of drying methods for agricultural products applying in traditional medicine. *International Journal of Science and Research Archive*, *11*(1), 180-188. https://doi.org/10.30574/ijsra.2024.11.1.0222

Vega-Gálvez, A., Uribe, E., Poblete, J., García, V., Pastén, A., Aguilera, L. E., & Stucken, K. (2021). Comparative study of dehydrated papaya (*Vasconcellea pubescens*) by different drying methods: Quality attributes and effects on cells viability. *Journal of Food Measurement and Characterization*, *15*(3), 2636-2647. https://doi.org/10.1007/S11694-021-00845-6

Yap, J. Y., Hii, C. L., Ong, S. P., Lim, K. H., Abas, F., & Pin, K. Y. (2020). Effects of drying on total polyphenols content and antioxidant properties of *Carica papaya* leaves. *Journal of the Science of Food and Agriculture*, 100(7), 2932-2937. https://doi.org/10.1002/JSFA.10320

Yap, J. Y., Hii, C. L., Ong, S. P., Lim, K. H., Abas, F., & Pin, K. Y. (2022). Degradation kinetics of carpaine and antioxidant properties of dried *Carica papaya* leaves as affected by drying methods. *International Journal of Food Engineering*, *18*(4), 265-274. https://doi.org/10.1515/ijfe-2021-0369

Yeomans, J. S., & Imanirad, R. (2014). A parametric testing of the Firefly algorithm in the determination of the optimal osmotic drying parameters for papaya. *2014 IEEE Symposium on Swarm Intelligence (SIS)*, 1-7. https://doi.org/10.1109/SIS.2014.7011770

Yudhistira, B., Adi, P., Mulyani, R., Chang, C. K., Gavahian, M., & Hsieh, C. W. (2024). Achieving sustainability in heat drying processing: Leveraging artificial intelligence to maintain food quality and minimize carbon footprint. *Comprehensive Reviews in Food Science and Food Safety*, *23*(4), e13413. https://doi.org/10.1111/1541-4337.13413

Zambra, C., Hernández, D., Reyes, H., Riveros, N., & Lemus Mondaca, R. (2021). *Kageneckia oblonga* leaves subjected to different drying methods: Drying kinetics, energy consumption and interesting compounds. *Frontiers in Sustainable Food Systems*, *5*, 641858. https://doi.org/10.3389/FSUFS.2021.641858

Zareiforoush, H., Bakhshipour, A., & Bagheri, I. (2022). Performance evaluation and optimization of a solar-assisted multi-belt conveyor dryer based on response surface methodology. *Journal of Renewable Energy and Environment*, *9*(1), 1-12. https://doi.org/10.30501/jree.2021.285697.1203

How to cite this Article:

Prashant Pandit and Nilesh Diwakar (2026). Optimization of Solar Drying Parameters for Nutrient Retention in *Carica papaya* Leaves: A Comprehensive Review. *International Journal of Experimental Research and Review, 50*, 165-172.

DOI : https://doi.org/10.52756/ijerr.2026.v50.013

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.